THE SNOWFALL OF THE UNITED STATES.[1]

By Prof. ROBERT DEC. WARD.

(Abstract.)

THE ECONOMICS OF SNOW.

"The margin of temperature difference between rain and snow is a narrow one. It is, however, one of the most critical points in man's relation to the atmosphere, because of the fundamental differences in the economic effects of rain and snow. Snow, especially the deep snows which lie for weeks and months on the mountains and plateaus of the semiarid West, furnish a slower, and therefore a more lasting, natural supply of water for power, for irrigation, and for general use than does rain, which has a quick run-off. * * * A winter snow cover prevents deep freezing of the ground, protects grasses and fall-sown crops, and provides spring moisture for growing vegetation. * * *

"When sufficiently deep and more or less permanent, snow makes sleighing possible, and greatly facilitates lumbering operations over the forested sections of the northern and northeastern States. * * * Heavy winter snows, on the other hand, interfere with railroad operation, sometimes causing serious and expensive interruption of transportation, and involving great expense for the removal of snow from steam and electric railroads, and from city streets. At the same time, such conditions furnish employment to thousands of men. * * * The demand for all kinds of rubber footwear in the States where snowfall is a common winter characteristic has given rise to one of the important manufacturing industries of the snow belt. The use of snowshoes and skis, for winter sports as well as for ordinary means of locomotion, is another result of a winter snow cover.* * *

THE MEASUREMENT OF SNOWFALL.

"What is needed is careful determination both of the depth of snow as it falls and also of the water equivalent of the snow when melted." Methods and gages have been discussed in some detail in the MONTHLY WEATHER REVIEW, May, 1919, **47:** 294–296; and p. 697 below describes a new snow sampler.

"In the matter of forecasting the amount of water available from snow, the rate of melting of the snow, as well as the amount of evaporation from the snow fields and from the surfaces of water-storage basins are obviously of great consequence." In the high Sierras, when there are low temperatures and little wind movement, the average loss by evaporation is about three-quarters of an inch per day. Relatively high temperature, active wind movement, and abundance of strong sunshine result in a loss of freshly fallen snow which may average 10 inches a day, and of old snow, 3 to 4 inches.

An average annual snowfall map of the United States prepared in 1912 by C. F. Brooks from observations at about 2,000 stations during the 15 winters, 1895–1910, is reproduced.[2] The map published as Chart J. B. K. XVII in this issue of the MONTHLY WEATHER REVIEW was originally prepared by J. B. Kincer from all available records in the western mountains and from the complete records east of the Rockies, for the period 1895–1914. Then it was revised slightly to bring it into conformity with certain obvious topographic influences, and the detailed maps of United States east of the Mississippi, 1895–1913,[3] and of New England, 1895–1916,[4] without, however, getting away from the basic averages for the 20-year period.

GENERAL CONDITIONS OF SNOWFALL.

"The major controls of snowfall in the United States are the temperature, the season of precipitation, the frequency and intensity of winter storms, the topography, the proximity to primary sources of moisture supply, such as the oceans and the Great Lakes, and exposure to damp winds. * * * Over nearly all of the eastern United States the northeast wind, being both cold and damp, is the chief snow bringer. A 'northeast snowstorm' is a familiar winter characteristic, especially along the Atlantic coast. * * * The heaviest snows usually come in February or even in March over the northern sections. The northwest winds, blowing on the rear of the storms, are plenty cold enough to give snow, but are generally too dry. Snow flurries, rather than deep and general snows, are therefore usually associated with them. Exceptions must, however, be made in the case of windward mountain slopes, as in the Appalachian area, and of places to leeward of the Great Lakes, where the northwest winds may bring heavy snowfalls."[5]

With these general controls in mind the distribution of snowfall is easily to be remembered. The limiting latitudes of regular and of occasional snowfall may be broadly generalized as follows:

Latitudes of general and of occasional snowfall.

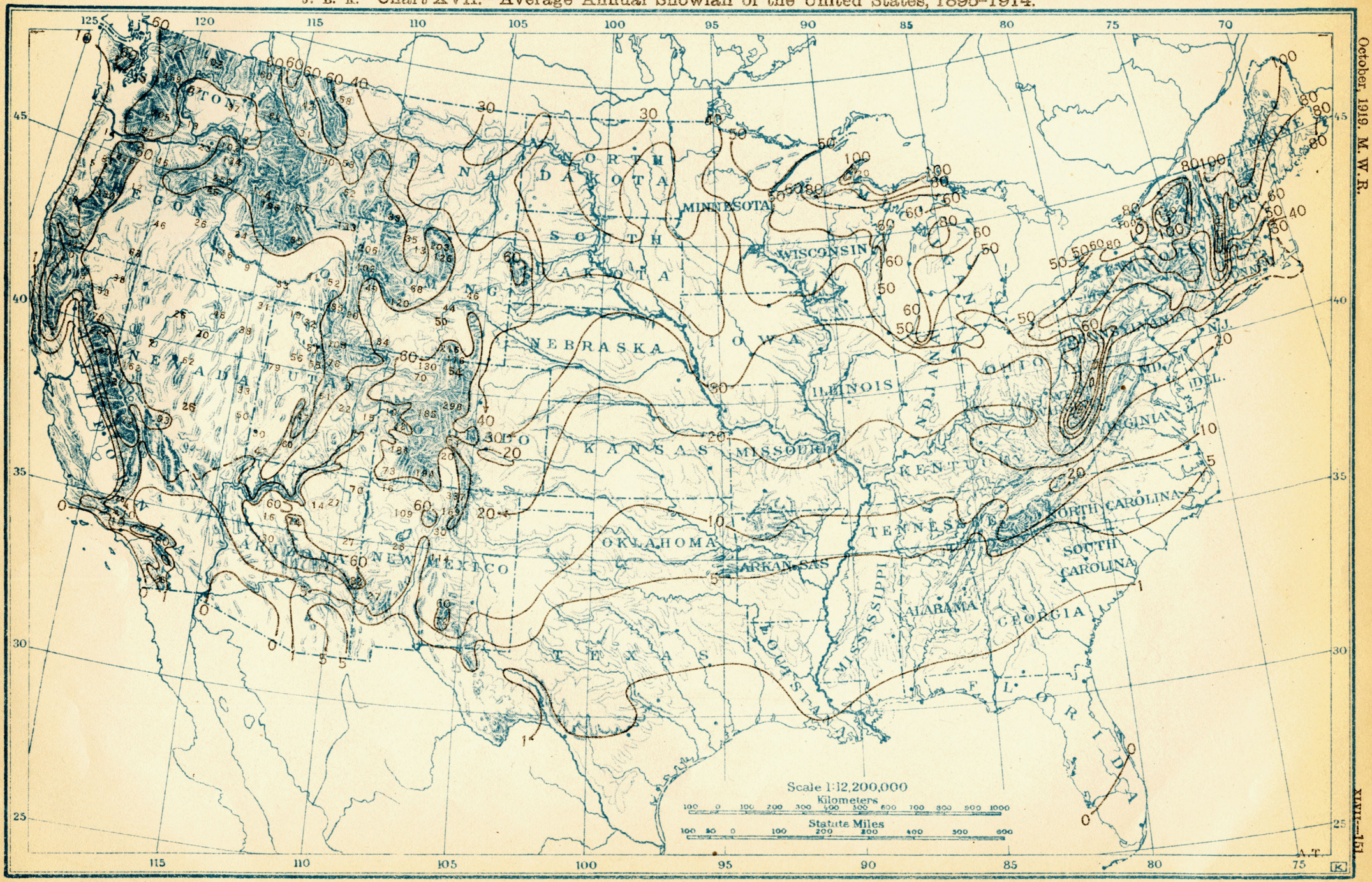
District.	Regular.	Occasional.
Pacific coast	45° (Northern Oregon)	34° (Los Angeles).
Interior	30° (Northern Gulf)	26° (southeast Texas).
Atlantic coast	35° (Hatteras)	29° (northern Gulf).

"From a practical point of view it may be said that snow does not occur in sufficient amount to lie unmelted on the ground south of San Francisco on the lowlands of the Pacific coast, or south of Cape Hatteras on the Atlantic coast. This statement, however, does not hold for inland districts, or for elevated areas. The southern boundary of a regular winter snow cover, in ordinary winters, may be put at about latitudes 41°–42° in the eastern United States, but occasional winters carry the snow cover a good deal farther south. It is one of the marked climatic characteristics of the eastern United States that snow not infrequently occurs unusually far south, in districts which have very mild winters. * * *

"The most striking general facts on the snowfall map are the effects of the topography in causing very heavy snowfalls on the western flanks of the Sierra Nevada and Cascade Ranges (exceeding 400 inches over considerable areas); the 'snow-shadow' effect of this western mountain barrier in causing a decrease in the depths of snowfall over the interior plateau districts as a whole, with larger amounts over the mountains and higher plateaus; the heavy snows of the Rocky Mountain system, averaging considerably less than on the Pacific coast mountains, but amounting to more than 100 inches over fairly large areas even as far south as northern New Mexico, reaching over 300 inches in southern Wyoming and 400 inches in

[1] *The Scientific Monthly*, Nov., 1919, vol. 9, pp. 397–415, map.
[2] First published in Quart. Jour. Roy. Meteorological Soc., Apr., 1913, vol. 39.
[3] C. F. Brooks, MONTHLY WEATHER REVIEW, Jan., 1915, 43: chart 23.
[4] C. F. Brooks, ibid., June, 1917, 45, fig. 30, p. 285.
[5] See articles with maps by C. F. Brooks, MONTHLY WEATHER REVIEW; 1914, 42: 318–330; 1915, 43: 2–11; 1917, 45: 271–285.

J. B. K. Chart XVII.—Average Annual Snowfall of the United States, 1895–1914.



October, 1919. M. W. R.

XLVII—151

parts of the Colorado Rockies. East of the Continental Divide the snowfall rapidly decreases again, the lines of equal depth extending in a general east-and-west direction under the control of latitude. The Appalachian mountains and plateaus carry the lines well to the south (50–100 inches from Maine to Maryland), while the warm waters of the Gulf Stream carry them northward along the coast as far as Cape Hatteras. In the vicinity of the Great Lakes, especially on their lee shores, and thence eastward along the Canadian boundary as far as New England, there is a relatively heavy snowfall (more than 100 inches in northern New England, and 80 to more than 100 inches on the lee shores of the Lakes). Excluding

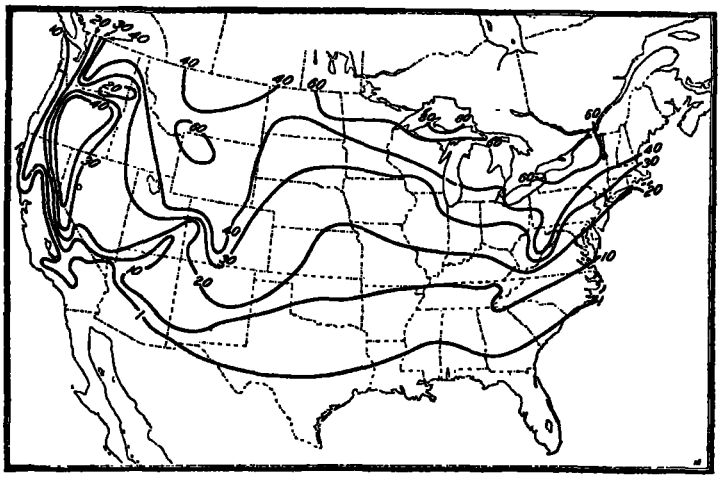


FIG. 1.—Average annual number of days with snow cover, 1895–1914.

the higher altitudes, the annual snowfall may be said to average roughly more than 20 inches over northern and less than 20 inches over southern sections. Most of this snow falls from December to March, but at the higher elevations, and in the northern States, it begins as early as October or even September, and falls as late as April or even May. In general, topography is seen to be the most striking control in the west, and latitude in the east."

SLEET AND ICE STORMS.

"Sleet and ice storms are so closely associated with snowstorms in the eastern United States that it is often difficult to forecast snow because a storm of sleet or ice may occur instead. Telegraph, telephone, and trolley wires, trees, sidewalks and streets are then covered with an icy coating. Service is thus often interrupted because of broken wires, and transportation becomes difficult or dangerous by reason of slippery rails and streets. Considerable damage is often done to forest and fruit trees by such ice storms. * * *

"The region of maximum frequency is over a broad central belt reaching from west of the Mississippi eastward and northeastward to the Atlantic. This is, in general, the portion of the country which is crossed by the principal storm areas, with their cold northerly winds to the north and warm southerly winds on the south of their centers. These conditions are essential to sleet formation. Severe sleet storms may occur from November to March, inclusive, and occasionally in April and October to the north of the 42d parallel. It appears that steep northward temperature gradients, and high temperatures over the Gulf and South Atlantic States are necessary for sleet formation, and are usually absent before and during heavy snowstorms. * * *"

A map of average annual number of days with snow cover, 1895–1914, by J. B. Kincer is reproduced as fig. 1, and one of days with snowfall, as fig. 2.

IS SNOWFALL DECREASING?

"There is a widespread popular belief in many parts of the country, especially in the earlier settled sections of the northeast, that less snow falls now than was the case years ago. In New England, for example, it is customary to speak of the 'old-fashioned New England winters' which brought many heavy snowstorms; when snow lay

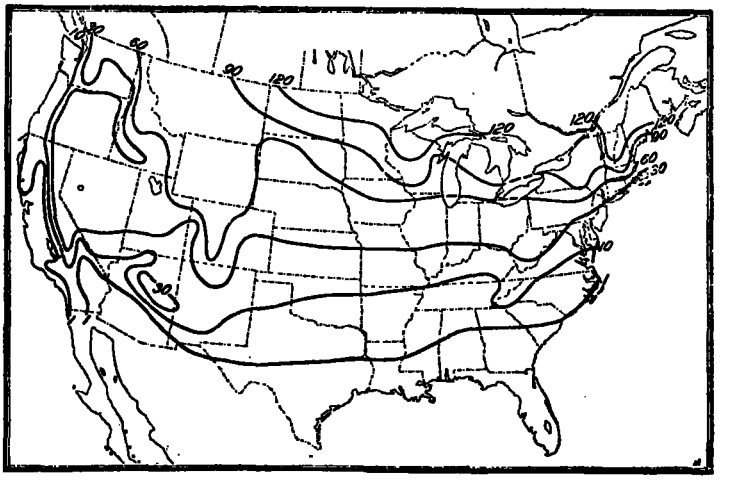


FIG. 2.—Average annual number of days with measurable snowfall, 1895–1914.

on the ground uninterruptedly all winter, and when sleighing was possible for three or four months without a break."[6] Impressions of snowstorms gained in childhood, particularly in the country, will not be equaled by those gained in adult life, especially if it is spent in a city. Great storms of history appear close together, just as telegraph poles seem to stand close together when we look back at them, but are some distance apart as they go by.[7]

Prof. Ward has done good service in presenting such an interesting summary of the subject, especially since it is so complete bibliographically. Half the references are to articles published in the MONTHLY WEATHER REVIEW since 1914.—*C. F. B.*

[6] Nevertheless, the winter of 1915-16 was in much of New England the equal of historic snowy ones. See "New England snowfalls" (C. F. Brooks), MONTHLY WEATHER REVIEW, June, 1917, 45:271–285, (30 figs.).—C. F. B.

[7] Centuries of history contain accounts of a number of snowy winters, but when the number of years is divided by the number of snowy winters, it is evident that a real "old-fashioned snowy winter" is to be experienced, on the average, only once in a lifetime.—C. F. B.